

LATTICE BOLTZMANN SIMULATION OF NANOFLUID IN SQUARE CAVITY

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“I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Master of Engineering (Mechanical)

To my beloved family

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ABSTRACT

In this study, lattice Boltzmann method is applied to investigate the natural convection flows utilizing nanofluids in a square cavity. Al₂O₃ and CuO water based nanofluids with 1, 3, 5 and 10% nanoparticle volume fraction is used as the fluid. This study has been carried out for the pertinent parameters in the following ranges: the Rayleigh number of nanofluid, $Ra=10^3$, 10^4 and 10^5 , the volumetric fraction of nanoparticles 1, 3, 5 and 10%, and the aspect ratio (Ar) of the enclosure is 0.5, 1.0 and 2.0. The effects of solid volume fraction of nanofluids on hydrodynamic and thermal characteristics are investigated and discussed. The average and local Nusselt numbers, streamlines, temperature contours and vertical component of velocity for different values of solid volume fraction and Rayleigh number are illustrated. Results show that by increasing Rayleigh number and nanoparticle volume fraction, average Nusselt number increases in whole range of Rayleigh numbers that lead to decreasing thermal boundary layer and enhancement of heat transfer of fluid in the cavity. As expected, Al₂O₃ with higher heat conductivity has higher Nusselt number with respect to CuO with lower heat conductivity.

ABSTRAK

Dalam kajian ini, kaedah kekisi Boltzmann telah digunakan untuk menyiasat aliran olakan semulajadi dengan menggunakan cecair nano dalam sebuah rongga segiempat. Cecair nano yang berasaskan Al_2O_3 dan CuO dengan 1, 3, 5, dan 10% pecahan isipadu zarah nano telah digunakan. Kajian ini telah dijalankan untuk parameter yang berkenaan: number Rayleigh untuk cecair nano, Ra , adalah 10^3 , 10^4 and 10^5 ; pecahan isipadu untuk zarah-zarah nano adalah 1, 3, 5, dan 10%; dan nisbah aspek (Ar) untuk kekandang adalah 0.5, 1.0, dan 2.0. Kesan-kesan pecahan isipadu pepejal cecair nano ini terhadap ciri-ciri hydro-dinamik dan terma telah disiasat dan akan dibincangkan. Nombor-nombor Nusselt purata dan tempatan, garisan-garisan arus, suhu kontur, dan komponen menegak halaju untuk nilai-nilai pecahan isipadu pepejal serta number Rayleigh yang berbeza juga akan ditunjukkan. Keputusan kajian menunjukkan bahawa peningkatan dalam nombor Rayleigh dan pecahan isipadu zarah nano turut akan meningkatkan nilai nombor purata Nusselt untuk keseluruhan lingkungan nombor Rayleigh. Keadaan sedemikian akan menyebabkan penyusutan sempadan lapisan terma dan peningkatan kadar pemindahan haba untuk cecair yang berada dalam rongga tersebut. Seperti yang diramalkan, Al_2O_3 dengan kekonduksian haba yang lebih tinggi turut memiliki nombor Nusselt yang lebih tinggi daripada CuO yang mempunyai kekonduksian haba yang lebih rendah.